

REMARKS

The present invention is a method for constructing a reservoir model representative of an underground reservoir, including discretizing the reservoir by a set of grid cells, and associating with the reservoir model a permeability field constrained by *a priori* geologic data and production data or pressure data obtained from well tests collected in the reservoir. The method constructs an initial reservoir model including generating a permeability field in accordance with a stochastic model coherent with the *a priori* geologic data; identifies zones inside the underground reservoir; calculates permeabilities of the zones, uses a simulator to simulate fluid flows for estimating simulated production data or simulated pressure data, and estimates corrections of the permeabilities for reducing a difference between the production data or pressure data obtained from well tests and the simulated production or simulated pressure data; propagates the corrections to the set of grid cells to the reservoir model by an iterative optimization process comprising minimizing a function which depends on the corrections, using a technique of gradual deformation of utilizations of the stochastic model; and uses the reservoir model, including the corrections propagated to the set of grid cells, to develop the underground reservoir.

Claims 27-42 stand rejected on new grounds of rejection.

Claims 27-28, 35 and 36 stand rejected by 35 U.S.C. §103 as being obvious over United States Patent 6,064,944 (Sarda et al) in view of U.S. Published Application US 2006/0020438 (Huh et al). These grounds of rejection are traversed for the following reasons.

With respect to claim 27, which is the only independent claim in this application, the Examiner reasons as follows:

Sarda discloses: 27. (Currently Amended) A method for constructing a reservoir model representative of an underground reservoir, including discretizing said underground reservoir by a set of grid cells, and associating with said reservoir model a permeability field constrained by a priori geologic data and production data or pressure data obtained from well tests collected in said underground reservoir comprising **(Fig 1 and description; col: 8 line: 55-57)**:

a) constructing an initial reservoir model including generating a permeability field in accordance with a stochastic model coherent with the a priori geologic data **(Abstract: “physically exploring the original reservoir based on the determined physical property”; col: 3 line: 12-15)**;

Sarda however does not fully disclose the following limitations, which are disclosed by Huh’s analogous simulation system.

b) identifying zones inside said underground reservoir **(Fig 2; para 41)**;

c) calculating permeabilities of said zones **(para 41)**,

using a simulator to simulate fluid flows for estimating simulated production data or simulated pressure data **(Fig 5A and description)**, and

estimating corrections of said permeabilities for reducing a difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure data **(para 104: “permeability-saturation relationship and dispersion level) were set to match the experimentally determined values”)**;

d) propagating said corrections to said set of grid cells of said reservoir model by an iterative optimization process comprising minimizing a function which depends on said corrections, using a technique of gradual deformation of realizations of said stochastic model **(para 0009)**; and

e) using said reservoir model, including said corrections propagated to said set of grid cells, to develop said underground reservoir **(col: 1 line: 11-13)**.

It would have been obvious to one of ordinary skill in the art <oil reservoir modeling> at the time of Applicant’s invention to combine the

references in order to have a finer granularity for the grids / zones. Thus, allowing, for a better and more accurate simulation, which in turn saves time and money associated with developing a reservoir based on incorrect or inadequate simulation outputs.

Sarda et al, which is assigned to the Assignee of the present application, discloses a method for simplifying the modeling of a geological porous medium crossed by an irregular network of fractures. The modeling of the geological porous medium provides a simplified procedure for calculating the dimensions of a block section equivalent to a 'horizontal' section of a natural fractured medium. The method is based upon the equivalent of a dual-porosity model to a fractured reservoir regarding flow behavior. The geometrical method disclosed is for determining an equivalent block based on multi-phase concepts. See column 4, lines 21-46.

Sarda et al base their model upon the utilization of physical characteristics of the original reservoir. See the Abstract and step a) of claim 1.

The following differences exist between Sarda et al and claim 27.

First, the data utilized by Sarda et al regarding "physical characteristics" is not disclosed as the claimed production data or pressure data. It is noted the Examiner suggests that Sarda et al disclose in Fig. 1 and in column 8, lines 55-57, "a method for constructing a reservoir model representative of an underground reservoir, including discretizing said underground reservoir by a set of grid cells, and associating with said reservoir model a permeability field constrained by *a priori* geologic data and production data or pressure data obtained from well test collected in said underground reservoir." It is submitted that Sarda et al do not disclose associating with a reservoir model "a permeability field constrained by *a priori* geological data and production data and or pressure data obtained from well tests in

said underground reservoir." Fig. 1 is described as disclosing "a known procedure for determining a regularly fractured medium equivalent to a real fractured medium as set forth in the brief description of the drawings and further, as set forth in column 2, lines 10-32. An analysis of the text describing Fig. 1, in column 2, does not describe anything suggesting the aforementioned subject matter.

Furthermore, step a) recites "constructing an initial reservoir model including generating a permeability field in accordance with a stochastic model coherent with the *a priori* geological data. The Examiner relies upon the Abstract and further column 3, lines 12-15. It is submitted that neither the Abstract nor column 3, lines 12-15, discloses the aforementioned subject matter. If the Examiner persists in the stated grounds of rejection, it is requested that he explain on the record how he is interpreting Sarda et al to disclose the subject matter of step a).

Step b) recites "identifying zones inside said underground reservoir." The Examiner relies upon Fig. 2 and paragraph [0041] of Huh et al. It is submitted that a person of ordinary skill in the art would not interpret Fig. 2 and paragraph [0041] of Huh et al to disclose the foregoing subject matter. What is illustrated in Fig. 2 is "a fine-scale geological grid model" which is understood by persons of ordinary skill in the art to be a grid that is described in paragraph [0028] of the Brief Description of the Drawings which "could represent the reservoir area of Fig. 1."

Moreover, paragraph [0041] states as follows:

Through advanced reservoir characterization techniques, the reservoir area **5** can be represented by gridcells on a scale from centimeters to several meters, sometimes called a fine-scale grid. Each gridcell can be populated with a reservoir property, including for example rock type, porosity, permeability, initial interstitial fluid saturation, and relative permeability and capillary pressure functions.

As is described therein, the methodology is to provide grid cells on a scale from centimeters to several meters, which can be populated with a reservoir property. Nowhere is there any indication that there is an identification of zones inside the underground reservoir disclosed in Fig. 2 or in paragraph 41. If the Examiner persists in the stated grounds of rejection, it is requested that he clarify on the record where Huh et al discloses the aforementioned subject matter.

Step c) of claim 27 recites "calculating permeabilities of said zones using a simulator to simulate fluid flows for estimated simulated production data or simulated pressure data". The Examiner relies upon Fig. 5A of Huh et al and its description in paragraph [0086]. Specifically, the Brief Description of the Drawings describes in paragraph [0031] that 5A "illustrates the effective coordination number, z on total oil recovery for a multiple-contact miscible flood simulating using the method of the invention." Moreover, the description of Fig. 5A in paragraph [0086] of Huh et al states "shows that increasing z results in reduced oil recovery." It is submitted that there is no description of calculating permeabilities of the zones using a simulator to simulate fluid flows for estimated simulating production or simulated pressure data.

Moreover, Sarda et al also do not disclose the utilization of a simulator in view of the disclosure in column 5 describing the known recovery function $Req(x)$ in two dimensions as an analytical formula. Accordingly, it is submitted that there is also no disclosure of Sarda et al utilizing the claimed "calculating permeabilities of said zones, using a simulator to simulate fluid flows for estimating simulated production or simulated pressure data and estimating corrections of said permeabilities for reducing a difference between said production data or pressure data obtained from

well tests and said simulated production data or simulated pressure data" as recited in claim 27.

Moreover, the Examiner's reliance on paragraph [0104] of Huh et al, reproduced below, is noted.

To evaluate the ability of the method of this invention to simulate the experimental coreflood data, the method of this invention was first applied to the FCM CO₂/Soltrol system. The parameters z , $D\alpha_{\text{solvent}}$, $D\alpha_{\text{Mlight}}$, were adjusted so as to obtain the best possible fit with the experimental data. $D\alpha_{\text{Mheavy}}$ was assumed to be equal to $D\alpha_{\text{Mlight}}$, for simplicity. The best fit was obtained for the selection $z=4.5$, $D\alpha_{\text{Mheavy,light}}=0.5$. Using the same parameters and assuming $C_y=10$, a simulation was carried out using the method of this invention for the CO₂/Wasson crude system. All simulation parameters (phase behavior, relative permeability-saturation relationship and dispersion level) were set to match the experimentally determined values (data obtained from Gardner et al.). The viscosity of the oil in the simulation was changed to mimic the Wasson crude and an oil/solvent viscosity ratio of 21. These results are plotted in **FIG. 10**.

Paragraph [0104] discloses "simulation parameters" which are phase behavior, relative permeability-saturation relationship and dispersion level are set to match experimentally determined values. However, it is submitted that this disclosure does not suggest "estimating corrections of said permeabilities for reducing a difference between said production data or pressure data obtained from well tests and said simulated production or pressure data." If the Examiner persists in the stated grounds of rejection, it is requested that he explain on the record how paragraph [0104] meets the foregoing language of step c) of claim 27.

Huh et al disclose a method for simulating a hydrocarbon-bearing formation and specifically "characteristics of a multi-component, hydrocarbon-bearing formation in which a displacement fluid having at least one component is injected to displace formation hydrocarbons." See the Abstract. Furthermore, the aforementioned method does utilize a multiplicity of grid cells which are populated by

properties as described in paragraph [0041] including permeability. However, Huh et al do not disclose the use of production data or pressure data obtained from well tests as recited in the preamble of claim 27.

Moreover, Huh et al do not disclose "calculating permeabilities of zones". The Examiner's reference to paragraph [0041] is submitted to not disclose the claimed calculating permeabilities of said zones using a simulator to simulate fluid flows for estimated simulator production data or simulated pressure data as recited in the first part of step c) of claim 27.

Moreover, it is submitted that neither of Sarda et al or Huh et al disclose the subject matter of step d) of claim 27. It is noted that the Examiner refers to paragraph [0009] of Huh et al, which is reproduced below, as disclosing "propagating said corrections to said set of grid cells of said reservoir model by an iterative optimization process comprising minimizing a function which depends on said corrections, using a technique of gradual deformation of realizations of said stochastic model."

The principle of numerical simulation is to numerically solve equations describing a physical phenomenon by a computer. Such equations are generally ordinary differential equations and partial differential equations. These equations are typically solved using numerical methods such as the finite element method, the finite difference method, the finite volume method, and the like. In each of these methods, the physical system to be modeled is divided into smaller gridcells or blocks (a set of which is called a grid or mesh), and the state variables continuously changing in each gridcell are represented by sets of values for each gridcell. In the finite difference method, an original differential equation is replaced by a set of algebraic equations to express the fundamental principles of conservative of mass, energy, and/or momentum within each gridcell and transfer of mass, energy, and/or momentum transfer between gridcells. These equations can number in the millions. Such replacement of continuously changing values by a finite number of values for each gridcell is called "discretization". In order to analyze a phenomenon changing in time, it is necessary to calculate physical

quantities at discrete intervals of time called timesteps, irrespective of the continuously changing conditions as a function of time. Time-dependent modeling of the transport processes proceeds in a sequence of timesteps.

What is disclosed in paragraph [0009] is numerically solving equations describing a physical phenomena by a computer. However, it is submitted that this subject matter does not suggest to a person of ordinary skill in the art "an iterative optimization process comprising minimizing a function which depends on said corrections, using a technique of gradual deformation realizations of said stochastic model".

It is submitted that Sarda et al do not disclose any of the steps of claim 27 when their disclosure is properly interpreted. Moreover, Huh et al do not disclose the deficiencies thereof in view of there being no disclosure of the use of production data or pressure data obtained from well tests, calculating permeabilities of zones, and use of a simulator to simulate fluid flows for estimated simulated production or simulated pressure data and estimating corrections of said permeabilities for reducing a difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure data and gradual deformation to optimize the reservoir model as recited in step d).

Moreover, the Examiner has not set forth any rationale why a person of ordinary skill in the art would be motivated to combine the teachings of Sarda et al and Huh et al for any reason. It is noted that Huh et al's system pertains to simulating characteristics of a multi-component hydrocarbon-bearing formation into which a displacement fluid is injected whereas Sarda et al pertain to a method of exploring a heterogeneous geological original reservoir by means of a transposed reservoir equivalent to the original reservoir with respect to a determined type of

physical transfer function known for the original reservoir without regard to injection of displacement fluid.

It is submitted that the field of application of Sarda et al and Huh et al is so diverse that a person of ordinary skill in the art would have no reason to combine the cited references except by impermissible hindsight. The Examiner's assertion that the combination allows for "a better and more accurate simulation, which in turn saves time and money associated with developing a reservoir based on incorrect or inadequate simulation outputs" has not been demonstrated to be something that a person of ordinary skill in the art would be objectively considered by a person of ordinary skill in the art when considering the teachings of Sarda et al and Huh et al.

Minor typographical errors have been corrected in the specification.

In view of the foregoing amendments and remarks, it is submitted that each of the claims in the application is in condition for allowance. Accordingly, early allowance thereof is respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 C.F.R. §1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (612.42904X00) and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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